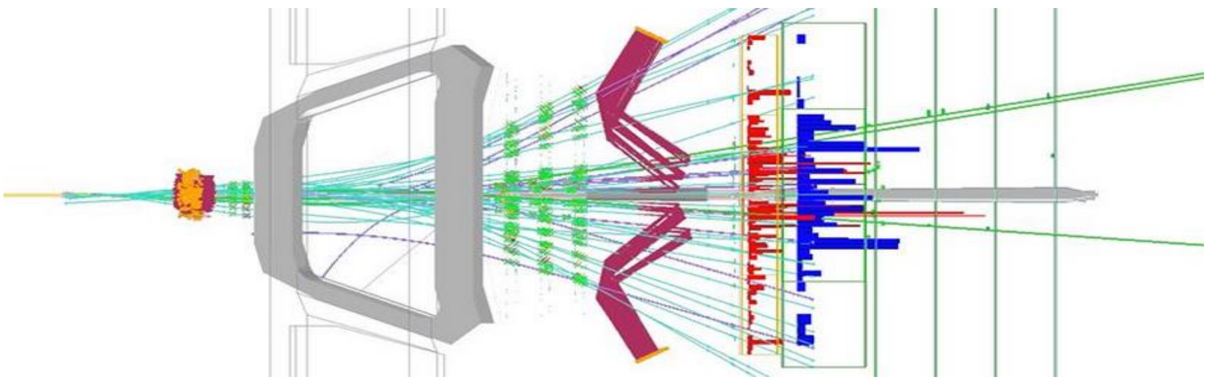
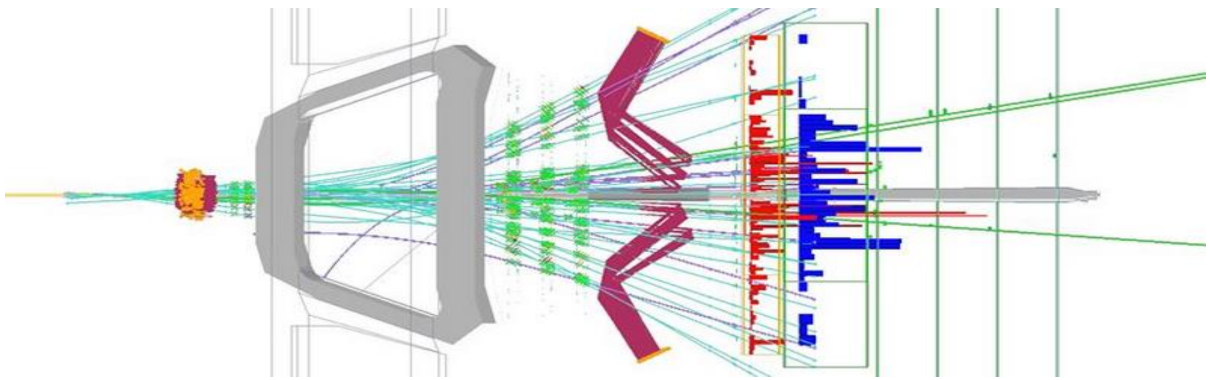
The search for rare and forbidden decays at the LHCb



Bartłomiej Rachwał
The Henryk Niewodniczański Institute of Nuclear Physics PAN, Kraków

The search for (almost) impossible at the LHCb



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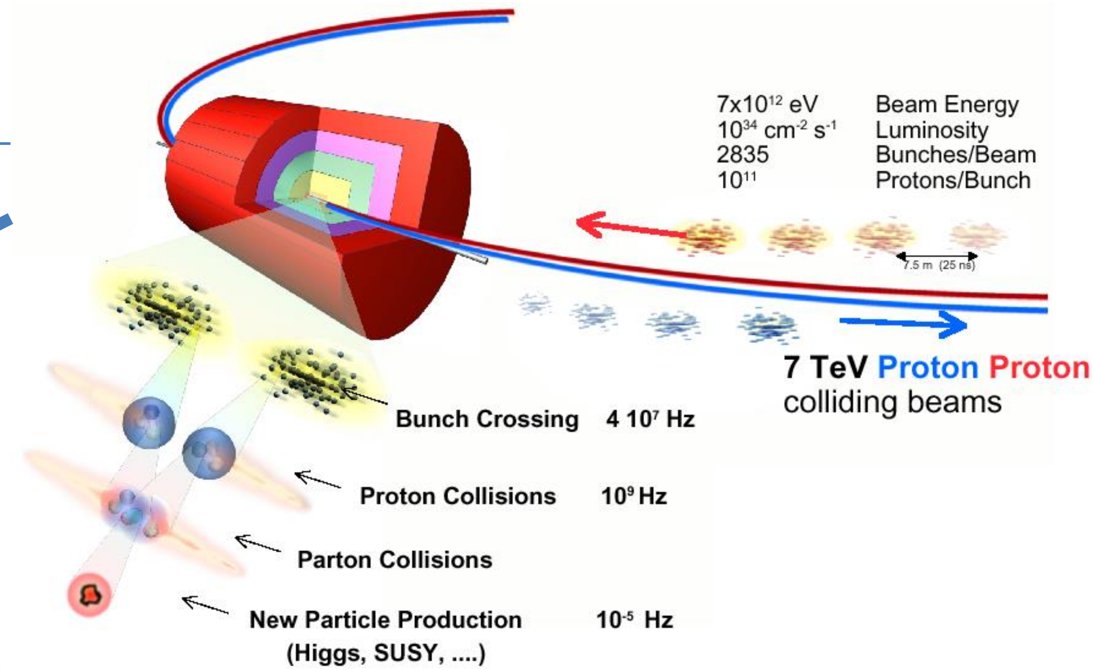
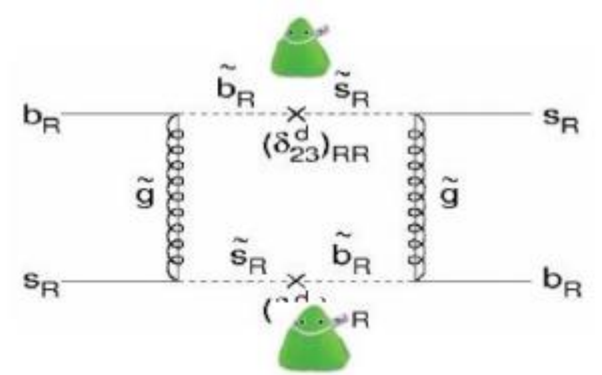
Probing of particles



The ways to find BSM Physics

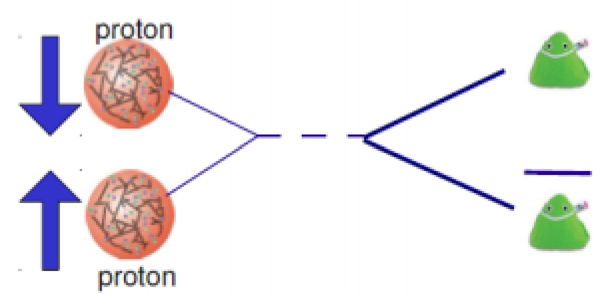
Indirect searches

New particles appearing as virtual particles in quantum loops



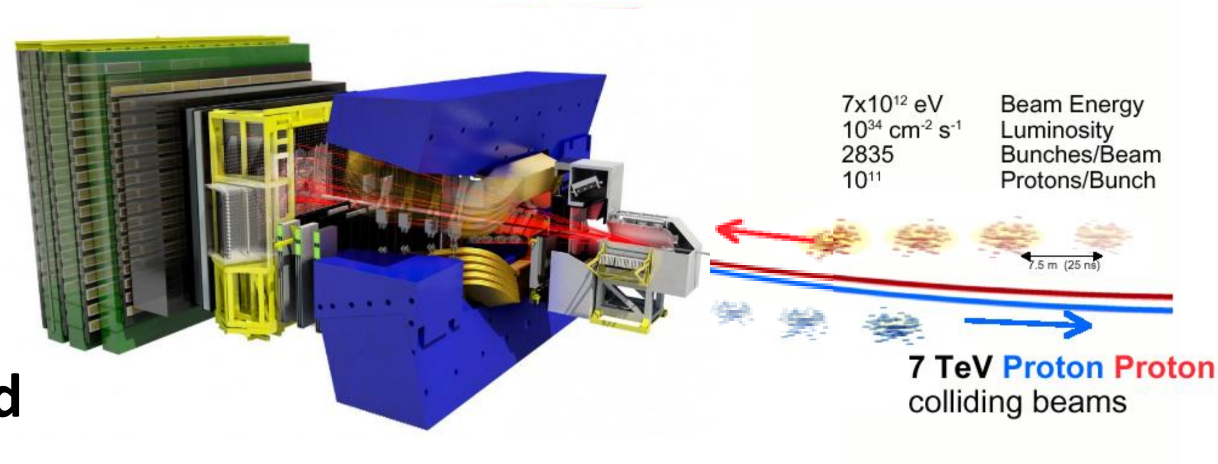
Direct searches

Produce new particles as real particles in pp collisions



BSM – Beyond **S**tandard **M**odel

The LHCb experiment



The ways to find BSM Physics

If BSM Physics is round the corner, then whereas the hints from flavour physics?

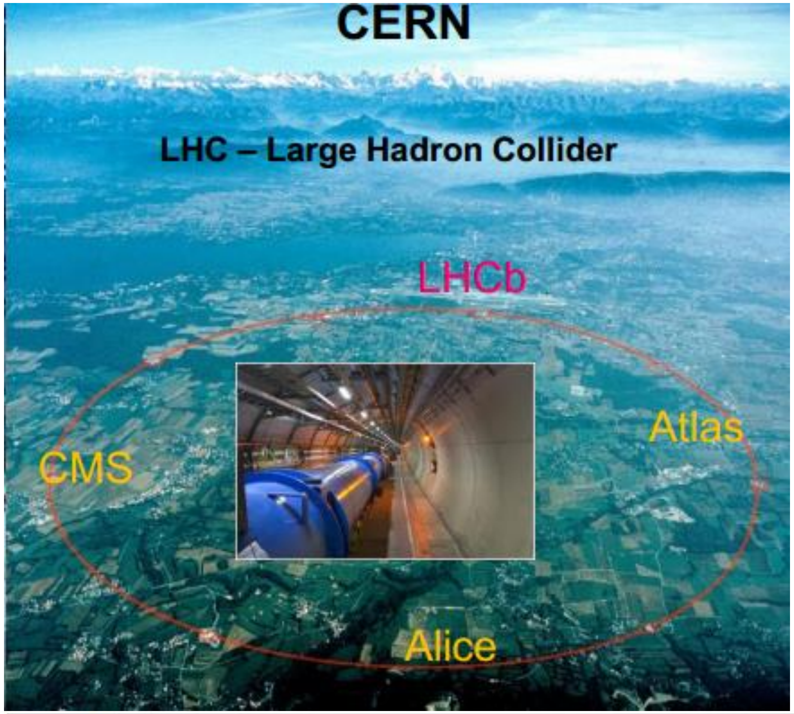
BSM Physics is either weakly coupled to flavour sector (MFV) or at a very high scale: important to probe energies beyond LHC.

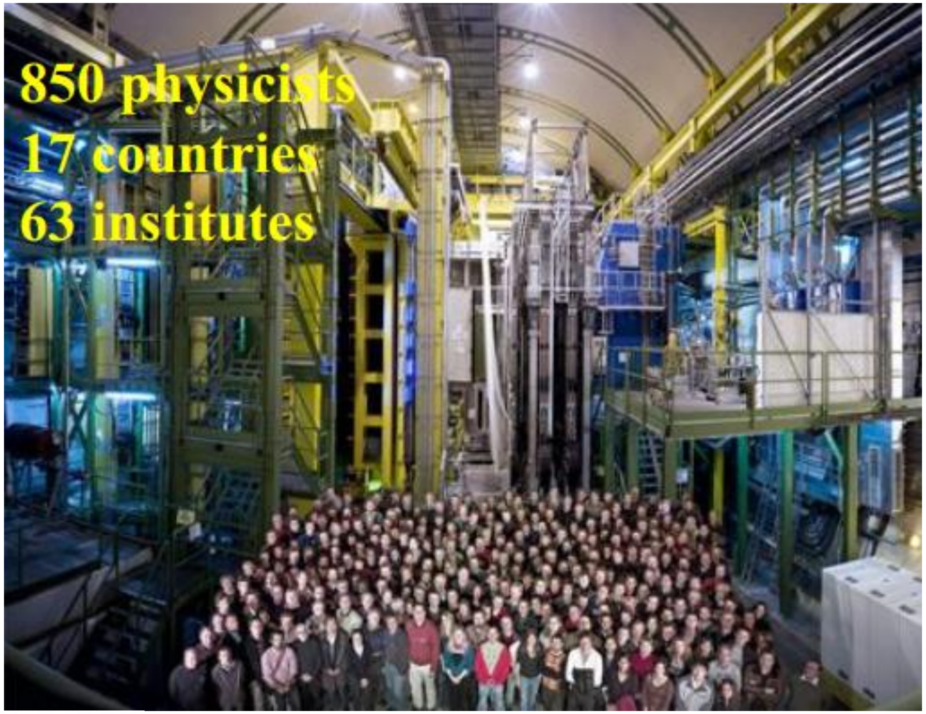
Do this by searching for decays that are (almost) impossible in the SM!

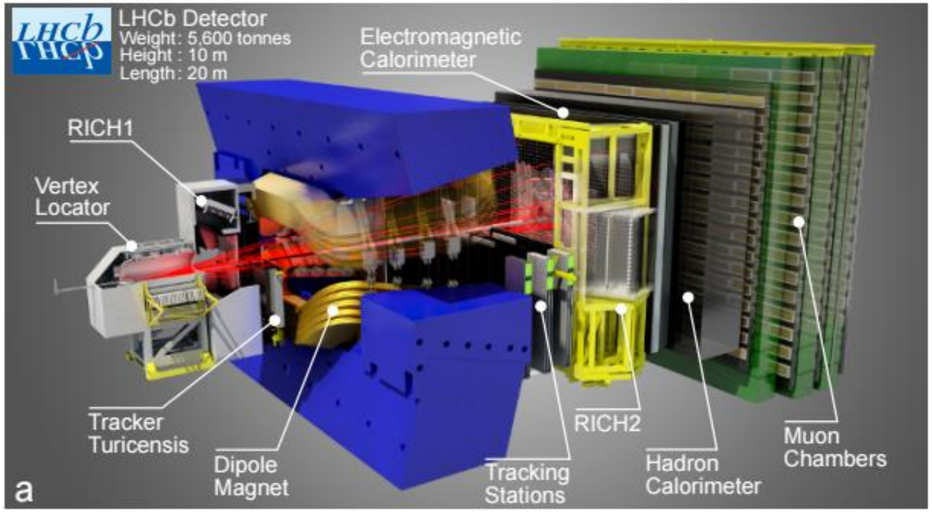
FCNC, LFV, BLV decays etc…

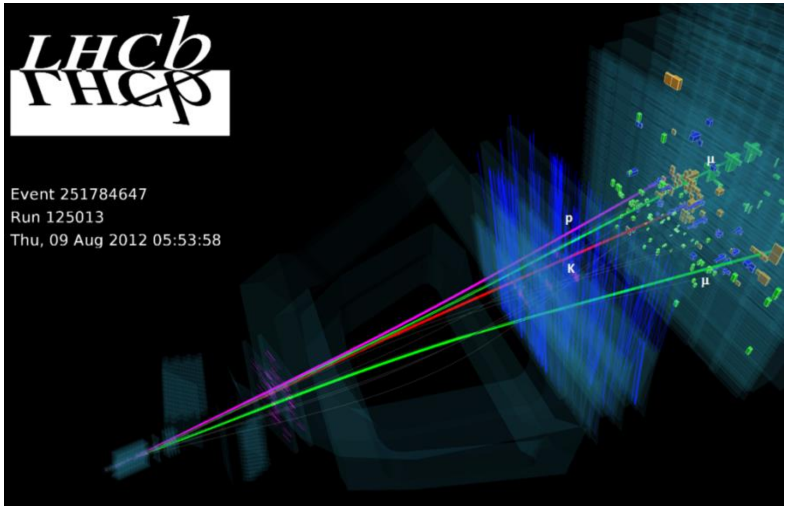
MFV – **M**inimal **F**lavour **V**iolation
FCNC – **F**lavour **C**hanging **N**eutral **C**urrent
LFV – **L**epton **F**lavour **V**iolation
BLV - **B**aryon **L**epton **V**iolation

The LHCb experiment





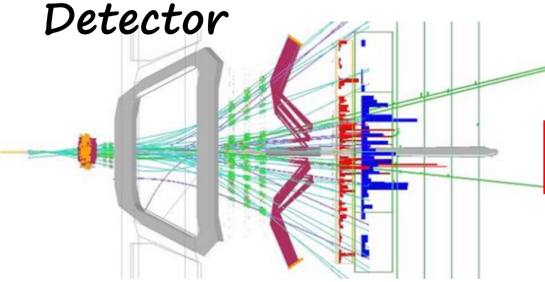




The LHCb data

40 MHz

Detector



35 GB/s
1 MHz

L0 Trigger

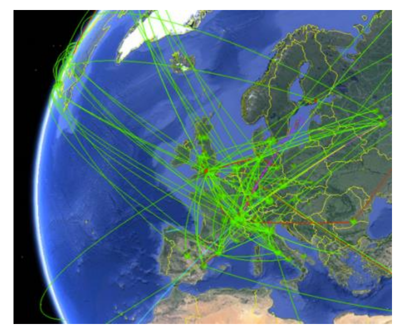
hardware

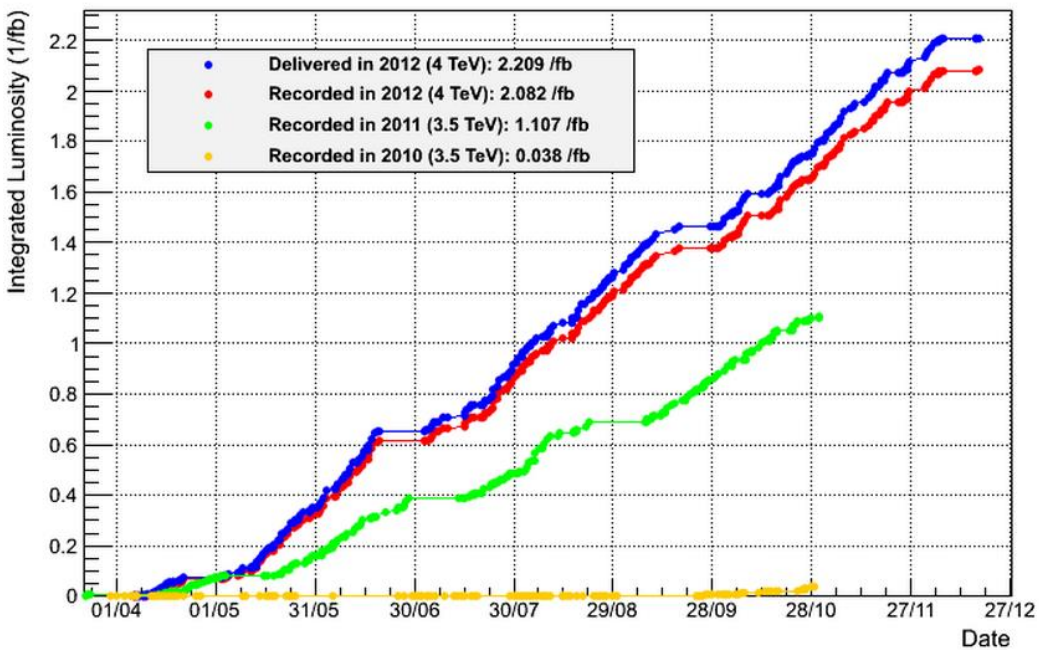
3 kHz

$2{\cdot}10^{10}$ events/year

Hight Level Trigger

Grid Computing





20 PB of data on permamnent storage !

In the case of rare decays the reduction factor of data have to be extremely high to select signal from overwhelming background

The LHCb data

Cyfronet resources play important role in HEP searches by contributing in the WLCG and allowing the local MC production *and final physics analysis.*

CYFRONET

Personal activity

Baryon and Lepton number violating decay:

$X_b^0 \to K^- \mu^+ \ (X_b^0 = \Lambda_\mathrm{b}^0, \Xi_\mathrm{b}^0, \ldots)$ ⇦ B. Rachwał PhD thesis

Is being finalized

Search for processes that violate baryon and lepton numbers can shed light on baryogenesis, the production of matter in early Universe.

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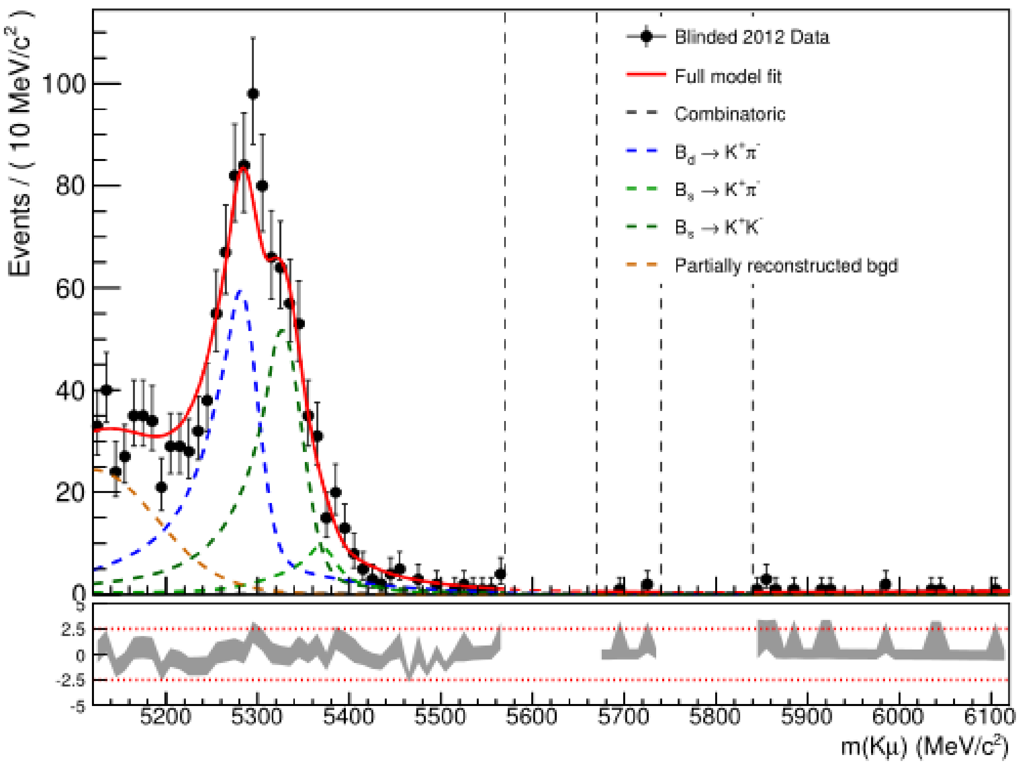

Personal activity

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$$\boldsymbol{X_b^0 \to K^- \mu^+} \ (\boldsymbol{X_b^0 = \Lambda_b^0, \Xi_b^0, \ldots})$$

The optimization of the event selection is performed in multidimensional phase space of parameters.

The final optimization relies on the scan over 3 variables and two data samples employing the statistical technique, the so called CLs method:

Get the expected CL (ie. exlussion limit) for the signal plus background hypothesis if there is only background.

In each step a complicated and CPU time consuming fit to data is employed.

The maximum sensitivity point of the measurement has to be determined by performing the parametric scan.

Personal activity

Baryon and Lepton number violating decay:

$$X_b^0 \rightarrow K^-\mu^+ \ (X_b^0 = \Lambda_b^0, \Xi_b^0, \dots)$$

Parametric scan

Figure of merit: Best Upper Limit on BR

Confidence levels:

$$CL_{s+b} = P_{s+b}(X < X_{obs})$$
$$CL_b = P_b(X < X_{obs})$$
$$CL_s = CL_{s+b} \,/\, CL_b$$

3 discriminating variables:

BDT x6 steps

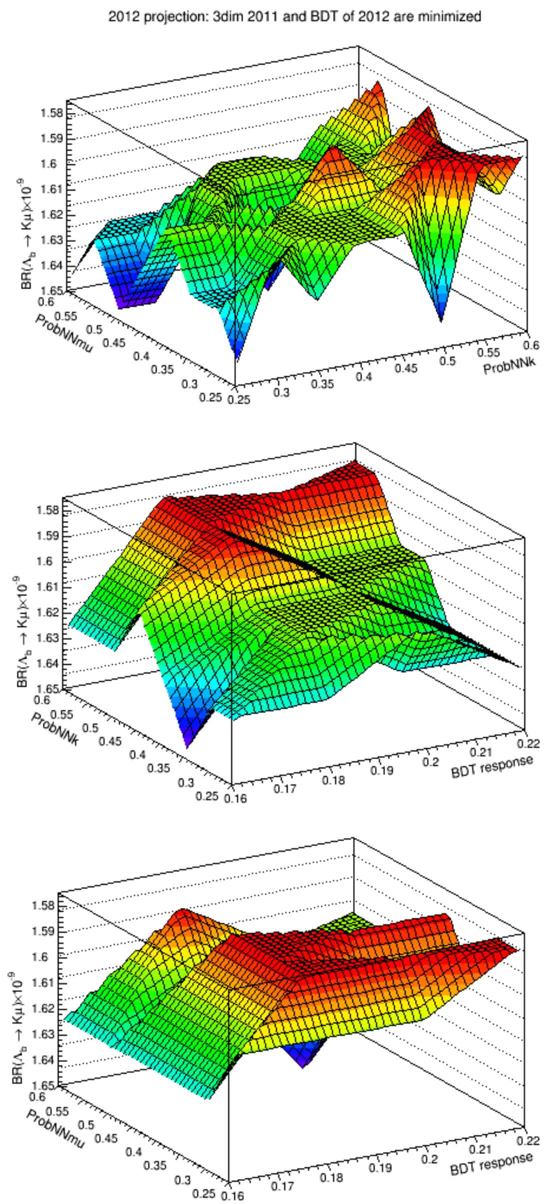
PIDk x8 steps

PIDmu x8 steps

→ 384 jobs

2 datasets:

→ 147'456 jobs × ~40 min = 98304 h (4096 days)



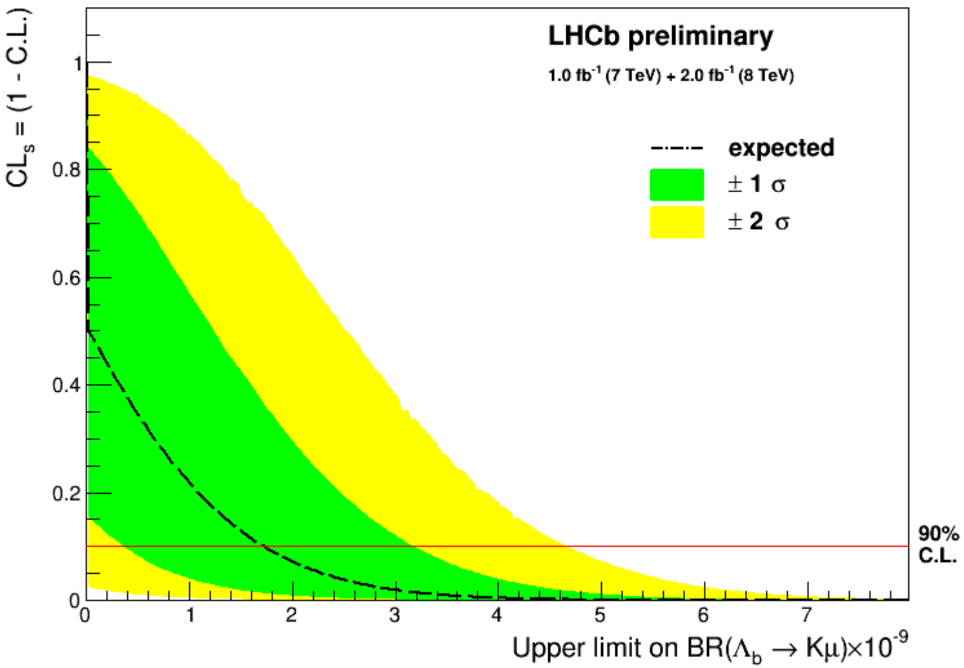
Personal activity

Baryon and Lepton number violating decay:

$$\boldsymbol{X_b^0 \to K^- \mu^+} \; (\boldsymbol{X_b^0} = \boldsymbol{\Lambda_b^0}, \boldsymbol{\Xi_b^0}, \dots)$$

The expected upper limit on branching fraction:

$$\mathrm{BR}(\Lambda_b^0 \to K^+\mu^-) = 1.575 \times 10^{-9} \; 90\% \; C.L.$$



Summary

The search for rare and forbidden decays at the LHCb

- ✓ Many interesting, **world-best results** from LHC Run 1
  - Most of them consistent with Standard Model.
  - New Physics is not yet discovered. We need more data.
- ✓ Expect many **exciting results** from Run 2 (2015-2017) when we will collect another 5 fb^{-1} at 13-14 TeV.
- ✓ **Polish Grid** resources extensively used.
- ✓ **Increased discovery potential in future!**